FY 2000 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 1999

BUDGET ACTIVITY: 2 PROGRAM ELEMENT: 0602234N
PROGRAM ELEMENT TITLE: MATERIALS, ELECTRONICS, AND COMPUTER TECHNOLOGY

(U) COST: (Dollars in Thousands)

PROJECT NUMBER &	FY 1998 ACTUAL	FY 1999 ESTIMATE	FY 2000 ESTIMATE	FY 2001 ESTIMATE	FY 2002 ESTIMATE	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	TO COMPLETE	TOTAL PROGRAM
Materials, Electronics, and Computer Technology	76,194	87,698	77,957	82,631	83,951	86,481	86,246	87,802	CONT.	CONT.

A. (U) MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This Program Element (PE) provides Applied Research to support all Navy advanced weapon and platform system concepts and needs in the areas of materials, electronics, and computer technology. Developmental tasks address significant improvements in terms of affordability; performance; reliability; high assurance computing; data; information and image processing; distributed collaborative network concepts; real-time computing; environmental impact; and advanced distributed manufacturing to effect transition of advanced technology to the Navy fleet. Development efforts are part of an integrated Department of Navy Science and Technology process managed by the Office of Naval Research.

(U) This PE develops enabling technologies to support most Joint Mission Areas, including:

- (U) Strike: advanced thermal management materials for most platforms to reduce weight and cost.
- (U) Littoral Warfare: acoustic signature reducing materials, torpedo warhead materials, vacuum electronics, solid state low noise amplifiers, network centric software, and high assurance computing, image and information processing and human computer interfaces.
- (U) Joint Surveillance: real-time targeting, connectivity, counter-jamming and deception, infrared sensors, broadband control components, fiber optics technology, high assurance computing, and network centric software.
- (U) Space and Electronics Warfare/Intelligence (SEW/I): lightweight and radiation-hard satellite materials, radio frequency (RF) solid state devices, high assurance computing, network centric software image and information processing and distributed collaborative groupware.
- (U) Strategic Deterrence: advanced ballistic missile launcher materials, RF solid-state devices for secure communications.

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- (U) Forward Presence issues: high temperature pavements for advanced aircraft, materials for condition based maintenance, RF solid state devices for secure communications, high power transmitters for precision strike, high assurance computing, and network centric software and decision aids.
- (U) Strategic Mobility: development of advanced distributed manufacturing capabilities and advanced long-life materials for repair of aircraft at sea, ultralight materials.
- (U) Land Attack Warfare: Common Tactical Picture (CTP), information exploitation and distribution, Fire Support Planning and Coordination, Weapon-Target Pairing, air and ground deconfliction and seamless Force coordination across C2 Command echelons and Warfare Commander's Forces who operate in both non-real-time and real-time regimes.

(U) In addition, this PE directly underpins the Readiness Joint Support Area and Support and Infrastructure Joint Support Area especially in the domains of affordability, environmental quality, and logistics. Programs include environmentally acceptable coatings for both aircraft and ships and the maintenance of the Navy pier and wharf infrastructure for surge capacity. This PE also contributes to lower system life-cycle costs through development of technologies that realize more compact, lighter weight electronic components, and reduction of cost, schedule and operational manpower in computer-centric systems.

(U) This PE supports the Office of the Secretary of Defense (OSD) Science and Technology (S&T) Investment Strategy in the following Future Joint Warfighting Capabilities: Real-Time Knowledge of the Enemy, Prompt Engagement of Regional Forces on Global Basis, Lower-End Actions, Space Control, and Countering Threat of Weapons of Mass Destruction; materials projects support affordable performance increases in radomes, infrared windows, advanced engines, and platform signature reduction to allow achievement of military objectives with minimum casualties and collateral damage; materials programs directly support lightweight, survivable satellite and spacecraft thermal control materials to positively affect the U.S. ability to control space usage. The PE is an integral part of the following Department of Defense (DoD) Technology Areas: Materials and Processes, Electronics, and Information Systems Technology. As a foundation technology area it has impact in most other DoD technology areas as well.

(U) Due to the sheer volume of efforts included in the PE, the programs described in the Accomplishments and Plans sections are representative selections of the work included in the program.

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(U) The Navy S&T program includes projects that focus on or have attributes that enhance the affordability of warfighting systems.

(U) JUSTIFICATION FOR BUDGET ACTIVITY: This program is budgeted within the APPLIED RESEARCH Budget Activity because it investigates technological advances with possible applications towards solution of specific Naval problems, short of a major developmental effort.

(U) PROGRAM ACCOMPLISHMENTS AND PLANS:

1. (U) FY 1998 ACCOMPLISHMENTS:

- (U) ($988) SHORE FACILITIES MATERIALS. Shore Facilities Materials provides technology for the structure of piers, wharves, Naval/Marine Air Station runways, and other facilities required by naval logistics and operations, such as magazines and tank farms. The work is focused on demonstrating affordable materials to increase the life and reduce maintenance costs of such facilities.
  - (U) Two corrosion demonstration test articles have been fabricated and installed for evaluation. A half-scale deck specimen utilizing two layers of corrosion resistant dual-phase steel was installed at Port Hueneme, California. A prototype cathodic protection system, prepared by an impressed current flame sprayed titanium process, was installed on a 900 square foot section of reinforced concrete at SUBASE San Diego pier 5002 for experimental evaluation. These innovations have the potential to substantially increase the time between repairs and reduce costs.
  - (U) Major structural-composite specimens were obtained and are being subjected to accelerate aging tests, which will produce the effects of two decades exposure in two years. This new procedure will permit the rapid convergence to new long life cost effective materials.

- (U) ($10,049) AIRBORNE MATERIALS. (Includes Congressional plus-up, for Second Source Carbon Fibers and Resin Transfer Molding) Airborne Materials provides technology for naval aircraft, including airframes, propulsion, and air weaponry. It is focused on those material issues associated with carrier landings, corrosion and affordability.
  - (U) Demonstrated single crystal/powder metal insertable bladed disk system materials for 1200° F compressors and 1450° F turbines. Subscale components such as a disk were successfully fabricated.

- (U) Demonstrated a process for low volatile organic (340 gram/liter) high solids self-priming topcoats for aircraft ground support equipment and identified procedures for reducing carbon dioxide generation. This development helps the Navy to respond to Environmental Protection Agency (EPA) restrictions on volatile organic compound content of paints.
- (U) Quantified the benefits of cyanate ester adhesives for rapid curing aircraft repairs. This reduces maintenance costs.
- (U) Designed sensor systems for condition-based maintenance monitoring of aircraft corrosion and health of corrosion preventive coatings. This provides needed technology for Navy implementation of condition based maintenance.
- (U) Demonstrated casting technology for large gamma-titanium aluminide structures with 150°F creep capability for first generation materials. This will lead to increased thrust-to-weight in Naval gas turbine engines.
- (U) Novel low thermal conductivity thermal barrier materials were demonstrated and directions for further development identified. The materials will result in enhanced life-times and performance for Naval gas turbine engines.

- (U) ($13,186) SEABORNE MATERIALS. (Includes Congressional plus-ups for Advanced Intelligent Materials Processing (Center, Titanium Powder Processing, Composite Submarine Shelter). Seaborne Materials provides technology for all ship, submarine, and related materials needs, including hull materials, machinery materials, coatings of all types, and seaborne weapons materials. This work provides the enabling capabilities for reduced cost and maintenance, improved performance, and reliable operations.
  - (U) Reformulated both silicone-alkyd and acrylic-latex Infrared (IR) reflective coatings using alternative pigments to BASF black pigment which has seen a ten-fold increase in price being charged to the Navy.
  - (U) Developed spray forming procedure for making 50%Cr-50% Ni alloy for incinerator applications to reduce the cost of alloy liners for VORTEX shipboard waste incinerators by $14,000 per liner.
  - (U) Designed new MIL-100S welding wire to minimize costly preheat and eliminate hydrogen cracking for more affordable and reliable ship and submarine construction with advanced high strength steels.
  - (U) Explored strength, fracture, and weldability characteristics of non-magnetic alloys for ship hull structures with reduced signature.
  - (U) Determined ballistic resistance of glass reinforced polyurethane as candidate lightweight, non-magnetic material for construction of ships with reduced signature.
  - (U) Explored advanced composites for submarine storage capsule applications.

- (U) Investigated self-canning of powder components via selective laser sintering of the surface.
- (U) Continued development and exploration of the plasma quench process to produce low cost titanium powder.

- (U) ($2,022) MISSILE/SPACE MATERIALS. Missile/Space Materials provides technology for tactical ballistic missile needs, including thermal management materials for power generation and protection, and spacecraft thermal straps and doublers. While this effort focuses on problems associated with naval systems, it is jointly planned and coordinated with Army, Air Force and Defense Advance Research Project Agency (DARPA) efforts.
  - (U) Feasibility of two alternative heat shield materials with ablation and insulation performance equivalent to state-of-the art rayon-base materials using blends of low cost carbon fibers was demonstrated. These are potential replacements for out-of-production heat shield materials.
  - (U) Developed cost effective fabrication processes for ceramic composites based on hafnium and/or tantalum materials. This will lead to better engine performance and reduced cost in Naval missile systems.
  - (U) Demonstrated the benefits of heat shield replacement materials that emphasize lower cost tape wrapped fabrication techniques. This offers low-cost replacement candidate for out-of-production heat shield materials.
  - (U) Developed low cost fabrication methods for ceramic materials for applications such as rocket nozzles.
  - (U) A processing technique for imparting high temperature strength to sapphire IR transparencies while maintaining excellent optical quality was demonstrated. Diamond and enhanced sapphire domes and windows will increase the attainable velocity of air to air and Theater Air Defense (THAD) missiles, which will result in improved lethality and survivability.

- (U) ($8,661) MULTI-MISSION MATERIALS. (Includes Congressional plus-ups for photomagnetic materials and Terfenol-D). Multi-mission materials provides developing technologies for promising naval applications such as biomolecular materials for antifouling coatings on ships. It also supports materials technologies for naval systems across a broad spectrum, such as laser eye and sensor protection as well as sensor/transducer materials for sonar and condition based maintenance applications.
  - (U) Tubule-based materials for controlled release-coating applications were developed and transitioned to industry. Such materials have the potential to control ship fouling and thus reduce fuel costs.
  - (U) Demonstrated high temperature composites based on fluorinated and non-fluorinated phthalonitrile polymers for high temperature application to multiple platforms. These materials were shown to meet fire specifications for shipboard use and thus permit new ship topside stealthy designs.

- (U) Evaluated metal-plated microtubules for electro-active coatings in antenna systems and demonstrated that they meet antenna isolation requirements. These materials were shown to be more cost effective and are scheduled for testing for fleet insertion on the EAGER.
- (U) Nanostructured WC/Co, YSZ, and oxide composite hard coatings were successfully fabricated by thermal spray on steel and aluminum substrates with significantly enhanced adhesion, toughness, and wear resistance. Nanostructured coatings will significantly reduce the cost of maintenance for ships, aircraft and land vehicles.
- (U) Equipment was purchased and installed in order to synthesize, for the first time, new photomagnetic materials and measure their properties.
- (U) Injection molding of 2-D acoustic receiver piezoelectric materials in arrays were demonstrated in diver hand held sonar devices. Such devices are critical to mine detection and removal.

• (U) ($7,665) RF SOLID STATE DEVICES AND CONTROL COMPONENTS. Provides for the generation, radiation, reception, control and processing of Ultra High Frequency (UHF), Very High Frequency (VHF), Microwave (MW), and Millimeter Wave (MMW) power for Navy all-weather radar, surveillance, reconnaissance, electronic warfare (EW), communications, and smart weapons systems. The technology developed cannot be obtained through Commercial Off the Shelf (COTS) as a result of the requirements placed on power, frequency, linearity, bandwidth, weight, and size. Beginning in fiscal year 1998 the Microelectronics thrust has been merged with RF Solid State and Control Components to highlight the increasing digital RF emphasis of Microelectronics.
- (U) Demonstrated low power W-band duplexer components for Navy’s 94 GHz radar program.
- (U) Developed design for highly compact, high Q, tunable bandpass filters and oscillators for transmit/receive (T/R) module applications.
- (U) Demonstrated InP-based heterojunction bipolar transistors for application to pulsed Ka-band phased arrays for dual mode electronic counter measures (ECM) resistant strike weapon conformal aperture.
- (U) Demonstrated the device technology for low power, low voltage sub 500nm – 250nm Complementary Metal Oxide Silicon (CMOS)/silicon germanium (SiGe) devices in 50nm thick Thin Film Silicon-on-Sapphire (TFSOS) for high performance A/D converters for smart sensors/weapons, space/missile/airborne electronics, advanced stand-off weapons and EW applications.
- (U) Continued development of the technology for low power, low voltage sub 250nm – 100nm CMOS/silicon germanium (SiGe) devices with T-gate structures in 50nm – 30nm thick Thin-Silicon-on-Sapphire (TPSOS) to achieve Ft, Fmax in the range of >70 GHz – 100 GHz. These devices will allow the development of 16 – 18 bit, 2 - 50

kilosamples/sec, <1 mw A/D converter for unattended deployable remotely controlled sensor systems for sonar and shallow water ASW applications.
- (U) Demonstrated the components of a 4-bit, 10 GSPS A/D based on 100nm minimum feature size CMOS TFSOS for EW and radar applications.
- (U) Continued development of analog very large-scale integrated (VLSI) continuous wavelet transform circuit for RF emitter identification
- (U) Continued to develop a 25 channel Continuous Wavelet Transform circuit for EW signal identification.
- (U) Continued to develop p-type doping of GaN grown by Orgono-Metallic Vapor Phase Epitaxy (OMVPE). This task will enable device programs that rely on the use of p-n junctions.
- (U) Continued to optimize the interface structure in resonant tunneling diodes grown in 6.1 Angstrom (A) materials in order to improve the peak-to-valley ratios and increase current densities.

- (U) ($11,000) VACUUM ELECTRONICS. Provides for the generation and reception of MW, MMW, and sub-millimeter wave power. The technology being developed is not available through COTS because of the power and size requirements.
  - (U) Demonstrated elements of an advanced design tool set for an electron gun/collector and helix Traveling Wave Tubes (TWTs) implementation.
  - (U) Demonstrated a high-power, moderate bandwidth gyro-klystron for the Navy's 94-GHz radar program.
  - (U) Continued development of a high-duty, wideband gyro-twystron to meet the requirements of MMW radar applications.
  - (U) Evaluated noise reduction techniques for a coupled cavity TWT for ship-based illuminator applications.

- (U) ($3,575) E/O TECHNOLOGY. Provides for the development of IR focal plane arrays to detect targets against various backgrounds; RF photonics technology to increase the bandwidth and reduce the size/weight of phased arrays; and IR transmitting fibers for EW applications. The technology being developed is not available through COTS, which is primarily focused at 1.3-1.55um whereas Navy requires electro-optic devices and components in the threat bands of 2.0-2.5, 3.5-5, and 8-12um.
  - (U) Continued to develop mid IR fibers to reduce impurity loss < 0.05 dB/m and total loss< 0.3 dB/m in the 3- 5um region with emphasis on ruggedized one-meter lengths of cabled fibers; demonstrate IR fibers for 8-12μm region with loss < 2 dB/m.

- (U) Continued to develop 256 x 256 dual band Infrared Focal Plane Array (IRFPA) with one midwave and one longwave band for the detection of targets in clutter.
- (U) Continued to develop a 256 x 256 adaptive IRFPA with high dynamic range on-chip electronics to implement on-chip nonuniformity correction to handle challenging imaging conditions such as an aerodynamically heated dome, both hot desert and cold sky, and shadows.
- (U) Continued to develop a 128 x 128 color discriminating IRFPA with two midwave bands for the detection of missiles against ground clutter.
- (U) Continued development of broadband, amplified photoreceiver for 6-20 GHz links for ECM and Electronic Support Measures (ESM) applications.

- (U) ($9,500) ADVANCED MULTIFUNCTIONAL RF SYSTEM SUPPORT TECHNOLOGY. With the advances that are currently being made in electronics there exists a strong opportunity to realize multifunctional systems that integrate the functions of radar, EW, and communications into a pair of transmit and receive apertures over a broad bandwidth. It should be noted that this program is in contrast to the Air Force (AF) and Joint Strike Fighter (JSF) programs in that it treats both the transmit and receive functions in separate apertures. This approach avoids the need for time allocation of different RF functions and therefore offers the opportunity for more massive integration of RF functions into the pair of apertures. As a result, this integrated thrust has been formed and the current program enhanced to capitalize upon ongoing and planned applied research to develop RF solid state and photonic devices. This program is coordinated with JSF and the AF and has an oversight group with representatives from Space and Warfare Systems Command (SPAWAR), Naval Air Systems Command (NAVAIR), Program Executive Office (PEO)DD-21, PEO Theater Air Defense/Surface Combatant (TAD/SC), Common Support Aircraft (CSA), N86 and N6. Specific efforts within this thrust include:
  - (U) Demonstrated a UHF high power circulator.
  - (U) Continued to develop Twystrode/klystrode-compatible field emitter arrays to reduce size of Microwave Power Module (MPM) for radar and EW applications.
  - (U) Evaluated several concepts for multifunctional operation of fiber optic beamformer with one and two-dimensional array.
  - (U) Demonstrated feasibility of achieving a structurally embedded antenna array that is optically controlled over multi-octaves of frequency and capable of being fed by a MW modulated optical fiber for use in next generation wide area surveillance systems.

- (U) Demonstrated the feasibility of a superconducting 10 MHz bandwidth Analog-to-Digital (A/D) converter operating with 14 bits of dynamic range for use in next generation wide area surveillance systems.
- (U) Developed the concept for a RF transmit and receive beamforming network capable of RF frequency independent beam steering over ± 60 degrees from boresight using photonic technology to control an antenna array. Characterize the performance of photonic technology components optimized for various beamforming architectures.
- (U) Designed 100 GHz logic-derived microwave synthesizer with integral beam former.
- (U) Designed low parasitic heterojunction bipolar microwave power transistor with 100 GHz Fmax and 50-200 volt breakdown voltage.

• (U) ($2,255) HIGH PERFORMANCE COMPUTING (HPC). This areas supports development of software processing in embedded, real-time, systems such as detection of targets in clutter for missiles or the extraction of unknown signals from background. Functional areas include all-weather non-cooperative target recognition, including Identify Friend or Foe (IFF), adaptive beam forming and control, advance discrimination, sensor data fusion, and image compression (10x improvement).
- (U) Demonstrated a cross-platform architecture for three dimensional (3D) Virtual Reality Environment that interacts with multiple displays.
- (U) Demonstrated a robust embedded algorithm which enables Regionally Partitioned Lossy/Lossless Image Compression, including a Feature Based Compression scheme, enabling region of interest target identification” for automatic target cueing.
- (U) Modified the COTS software package, Private Eye to enable multichannel segmentation (including: two spatial, two spatial and time, ladar range and intensity) to allow fusing of information across multispectral IR bands with applications in the area of motion analysis and image registration.
- (U) Demonstrated version 1 of the Systems of Systems development software which includes compression and automatic processing for possible retargeting applications.
- (U) Demonstrated a robust software application suitable for preventing network traffic analysis attacks on Navy SIPRNET and commercial Internet communications.

• (U) ($2,708) ARTIFICIAL INTELLIGENCE AND HUMAN COMPUTER INTERACTION (AI/HCI). This area supports the development of generic technologies for a large number of application and mission areas that require reasoning under uncertainty (incomplete information, erroneous information, etc), sometimes in unprecedented situations. These are extremely

critical to decision making, training, diagnostics, human-computer interaction, and robot control applications and functions.
- (U) Demonstrated a Java-based case-based reasoning tool for solving interactive decision aids tasks. Integrated the Java-based case-based reasoning tool with another tool, PARKA, to support dialogue inferencing; modified the tool to solve crisis response tasks and applied the tool to a United States Marine Corps (USMC) recruiter training task.

- (U) ($4,585) ENGINEERING OF COMPLEX SYSTEMS (ECS). This area supports the development of a set of tools that will support the evaluation and assessment of large, complex systems including (1) an integrated measurement and instrumentation framework for reliability, metrics identification and validation, and performance modeling at the component and system level, and (2) a consistent framework for requirements specification, design capture, design optimization and system specification and assessment.
  - (U) Demonstrated the Engineering of Complex Systems toolset and transitioned to the DD-21 Program Office (PMS-500). These tools will be used to define the set of requirements for the DD-21 acquisition program.
  - (U) Demonstrated a Portable Common Interface Set prototype (Version 2) [PCIS2], emphasizing the use of COTS components and standards, as a US-France wide-area network software development system. This software provides for requirements traceability, configuration management, software process support, and the low-cost production of Defense Information Infrastructure Common Operating Environment compliant software. This will be used to develop coalition warfare software.
  - (U) Demonstrated a software tool that a developer can use to specify both timing and functional behavior in requirements specifications and applied the tool to the Operational Flight Program (OFP) of a Navy attack aircraft.
  - (U) Completed an empirical study showing the effectiveness of three formal techniques--term rewriting, Binary Decision Diagrams, and a constraint solver--that automatically detect serious errors (such as missing cases and instances of ambiguity) in software specifications containing numbers and arithmetic. Used one of the techniques to automatically detect over 100 instance of ambiguity in the requirements specification of an Operational Flight Program of a Navy attack aircraft.
  - (U) Devised several concepts for remote measurement of ocean wave slope. Slope information is necessary for accurately aiming the gun on the Rapid Airborne Mine Clearance System (RAMICS) anti-mine system.

2. (U) FY 1999 PLAN:

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- (U) ($891) SHORE FACILITIES MATERIALS.
  - (U) Determine the durability of composite materials through characterization and material studies for waterfront upgrades of reinforced concrete structures to reduce the maintenance costs and increase the lifetime of these Naval facilities.
  - (U) Design test protocols and conduct tests to characterize mechanical characteristics of prestressed carbon tendons and to quantify effects of material parameters on durability of modular hybrid composite/concrete structural systems for long applications in long life piers.

- (U) ($7,966) AIRBORNE MATERIALS.
  - (U) Explore the benefits of beryllium-aluminum and berylium-titanium alloys for aircraft applications.
  - (U) Demonstrate fabrication technology for compressor outer vane/diffuser using cast gamma titanium aluminides. This will result in increased performance and decreased cost in Naval aircraft engines.
  - (U) Complete demonstration of 1500°F Ni-turbine disk alloy. This will lead to increased performance (thrust-to-weight) for Naval gas turbine engines.
  - (U) Continue development of low volatile organic (340 gram/liter) self-priming topcoat for aircraft ground support equipment using new procedures for compliance with EPA air quality regulations.
  - (U) Explore cost effective processing routes for high strength diamond material for applications such as infrared missile domes and windows.
  - (U) Investigate applique technology for aircraft corrosion prevention to reduce hazardous waste enerated by paint removal.
  - (U) Evaluate corrosion sensor systems for condition based maintenance implementation on operational aircraft.

- (U) ($18,115) SEABORNE MATERIALS. (Includes Congressional Plus-ups for Advanced Intelligent Materials Processing Center, High Temperature Superconductors for Propulsion, and Micronization of Materials (coal)).
  - (U) Explore improved anticorrosive coatings for non-magnetic ship hulls required for stealth and mine countermeasures.
  - (U) Explore corrosion sensors for ship ballast tanks for implementation of condition based maintenance.
  - (U) Identify materials upgrades for long life seawater valves for life cycle cost reduction.
  - (U) Explore guided wave ultrasonics for detecting corrosion/erosion in shipboard piping without removing insulation for implementation of condition based maintenance.

- (U) Demonstrate self-canning of powder components via selective laser sintering of the surface.
- (U) Explore the dynamic strength and fracture resistance of very low interstitial titanium alloys for ship and submarine application to enhance survivability.
- (U) Evaluate strength, fracture, and weldability characteristics of non-magnetic stainless steel for ship hull structures for signature reduction.
- (U) Design, fabricate and test improved fender system using fiber reinforced urethane composites.
- (U) Investigate fire resistance and low velocity impact damage of carbon reinforced polyurethane as candidate lightweight, non-magnetic material for construction of ships for signature reduction.
- (U) Demonstrate new MIL-100S welding wire designed to enable more affordable and reliable welding of high strength steels in ship and submarine construction through reduction of preheat and elimination of hydrogen cracking for construction and maintenance cost reduction.
- (U) Develop improved models of deformation and fracture of hull materials, for incorporation into computer codes to simulate response of ship and submarine structural materials to underwater explosion, in cooperative program between U.S. and Germany.
- (U) Explore advanced hydrogen management techniques in regard to overall enhancement of cracking resistance in next generation high strength steel welds for ship and submarine construction for maintenance cost reduction.

- (U) ($2,763) MISSILE/SPACE MATERIALS. (Includes Congressional Plus-up for Carbon-Carbon Materials for Reentry Vehicles).

- (U) Demonstrate fabrication technology for affordable and reliable low cost hybrid materials for reentry vehicle heatshield applications. This will result in lower cost replacements for no-longer produced heat shield materials.
- (U) Demonstrate the benefits of ceramic materials for protection of propulsion components and other high temperature impingement applications in terms of predictive models and material screening test development. This will result in reduced cost and improved engine performance for Naval missiles.
- (U) Evaluate advanced ceramic materials in rocket environment. This will result in higher operating temperatures and greater reliability for Naval missiles.

- (U) ($8,908) MULTI-MISSION MATERIALS. (Includes Congressional Plus-ups for High Thermal Conductivity Fibers for Thermal Management Materials).

- (U) Develop phase one computer program to model non-linear optical materials in optical limiting devices for laser eye protection. Such materials have the potential for frequency agile protection for Marine Corps.
- (U) Demonstrate a system and controlling software for a reliable ultrasonic tomography that alleviates the problem of refraction to increase the ability to rapidly inspect aging platforms.
- (U) Demonstrate improved processing technology to reduce the cost of microtubule materials and composites for advance shipboard applications.
- (U) Identify critical Navy applications in weapons guidance devices for new single crystal high strain piezoelectric crystals for mine detection and removal.
- (U) The use of nanostructured tungsten carbide cobalt (WC/Co) coatings will be demonstrated by fabrication and testing of selected prototype components. Development of techniques for fabrication of nanostructured ceramic and aluminum matrix composite coatings will be carried out. Production of nanostructured feedstock materials will be scaled up to pilot plant capacity. This will result in maintenance cost reduction due to repair versus replacement for ship and submarine machinery components.

- (U) ($12,737) RF SOLID STATE DEVICE AND CONTROL COMPONENTS. (Includes Congressional Plus-ups for Superconducting Waveform Generator and Silicon Carbide Semiconductor Materials).
  - (U) Demonstrate 80 kW W-band duplexer for Navy's 94 GHz radar program.
  - (U) Develop design parameters for heterojunction varactor to be used in highly compact, high Q, tunable bandpass filters and oscillators for T/R module applications.
  - (U) Develop InGaP/GaAs heterojunction bipolar transistors for application in pulsed Ka-band phased arrays for dual mode, ECM resistant hyper-velocity strike weapon conformal aperture.
  - (U) Demonstrate the device technology for low power, low voltage sub 500nm – 250nm CMOS/SiGe with T-gate structures in 50nm thick TFSOS. These devices, which have frequency performance (Ft, Fmax) in excess of 50 GHz, allow the development of RF analog front end receivers, 16-bit, 125 megasamples/sec and 10-bit, 2.6 gigasamples/sec A/D converters, for digital receivers (X-band)/EW/Communication/signal intelligence.
  - (U) Demonstrate the analog portion of the very low power (<0.4 mw) high-resolution (16 – 18 bit) 2 – 5 kilosamples/sec A/D converter for sonar, shallow water Anti Submarine Wafare (ASW) applications.
  - (U) Demonstrate components of 16 bit, 125 megasample/sec A/D converter for application to wide bandwidth digital ASW receiver to meet Navy multi-channel acoustic system requirements.
  - (U) Develop a 25 channel Continuous Wavelet Transform circuit for EW signal identification
  - (U) Develop 6.1 Angstrom (A) materials for high frequency applications.

- (U) Develop 25 watt Gallium Nitride (GaN) X-band amplifier for high power transmitter applications
- (U) Develop gallium nitride heterojunction field effect power transistor for 6 - 18 GHz operation for next generation E/M power amplifiers.

- (U) ($10,000) VACUUM ELECTRONICS.
  - (U) Develop a high average power, moderate bandwidth gyro-klystron for the Navy 94-GHz radar program.
  - (U) Develop a 2D/3D electron gun and collector design code for vacuum devices.
  - (U) Develop an ultra-wide band vacuum power booster for EW applications.
  - (U) Develop a high-duty, wideband gyro-twystron to support radar and EW applications at millimeter-wavelengths.

- (U) ($5,511) E/O TECHNOLOGY.
  - (U) Develop a 256 x 256 adaptive IRFPA
  - (U) Develop optical microwave link with 50 mw output using <2.0V Vpi external lithium niobate modulators at 20 GHz.
  - (U) Develop 3 band IR detector to enhance performance against countermeasures and stealthy targets.
  - (U) Develop mid-IR fibers with loss < 0.2 dB/m in the 2 - 5 μm region and improve fiber fabrication techniques to achieve high tensile strength fibers. Reduce fiber defects and optimize fiber preparation to achieve power damage threshold > 1.2 GW/cm^2. Develop broadband, high damage threshold AR coatings for 2 - 5 μm region. Develop cabling techniques for ruggedized, thermally tolerant one-meter cables.
  - (U) Evaluate InAs/InGaSb growth techniques and transfer the techniques to industry and device technology programs.

- (U) ($10,500) ADVANCED MULTIFUNCTIONAL RF SYSTEM SUPPORT TECHNOLOGY.
  - (U) Develop CW ultra broadband (1 - 18 GHz), ultra linear (cross modulation products 28 dbm below fundamental signal) compact amplifiers suitable for use in next generation wide area surveillance systems.
  - (U) Develop a superconducting A/D capable of 19 bits of dynamic range over a 20 MHz spectrum for use in reducing background clutter in littoral warfare surveillance operations.
  - (U) Develop a RF transmit and receive beamforming network for the generation of simultaneously multiple frequency independent RF beams capable of beamsteering over ± 60 degrees from boresight on transmit and receive with control structure that preserves a 500 MHz instantaneous RF bandwidth for each beam.
  - (U) Implement concept for 100 GHz logic-derived microwave synthesizer and design integral phase and frequency modulator for synthesizer for 1 - 5 GHz output signals.

- (U) Fabricate from wide bandgap semiconductors and begin testing of low parasitic bipolar microwave power amplifier.

- (U) ($9,129) COMMAND AND CONTROL AND COMBAT SYSTEMS. Beginning in FY99, the HPC, the AI/HCI, and the ECS programs will be restructured into an integrated program entitled Command and Control and Combat Systems. This consolidation reflects a change in programmatic emphasis towards the direct support of Network Centric Warfare. Scientific domains of interest include (1) dependable and high assurance computing; (2) image processing and information exploitation; (3) visualization of the Common Operational Picture (COP)/Common Tactical Picture (CTP) including virtual reality environments; (4) decision support and collaboration; and (5) networked engagement and operations. The focus is on high assurance requirements specification and requirements testing, image compression and feature recognition, 3D virtual displays, architectures to merge Command and Control and Combat Systems, and distributed software development to support Defense Information Infrasturcture Common Operating Environment (DII-COE) systems such as the Global Command and Control System (GCCS).
  - (U) Incorporate intelligent agents into 3D virtual reality architecture to control interactions and data flow between entities.
  - (U) Develop collaborative software for combat system applications with allied and coalition countries leading towards interoperable systems.
  - (U) Demonstrate the ability to fuse image and defense terrain elevation data to produce improved maps supporting targeting and mission planning. Apply techniques to produce image mosaics with variable spatial resolution.
  - (U) Demonstrate the feasibility of using ocean wave slope measurement by remote wave sensing in the littoral region (shallow water) towards improving the RAMICS anti-mine system. Devise, implement, and test a methodology for removal of capillary wave distortions in airborne lidar images of underwater mines.
  - (U) Demonstrate version 2 of the “System of Systems” software and evaluate the joint effects of compression and noise upon data link performance. Modularize the compression algorithms, template design algorithms, and communications channel models and perform Monte Carlo simulations to analyze the effects of compression on the quality of the templates generated.
  - (U) Demonstrate a case-based reasoning toolset and integrate it with Stanford’s INCA planner/scheduler for hazard materials spills; Develop automated methods for a case authoring task within the toolset and integrate with other systems to support interactive Command, Control, Communications, Computer, and Intelligence (C4I) plan authoring and monitoring.
  - (U) Design and test a prototype software tool which uses three formal techniques (term rewriting, Binary Decision Diagrams, and a constraint solver) to automatically detect errors in software requirements specifications containing

variables of different types (real, integer, Boolean, and enumerated); analysis of such specifications is not feasible with current technology.
- (U) Demonstrate flexible techniques to significantly reduce vulnerability of Navy Internet traffic to traffic flow analysis, making it difficult for commercial Internet routers to determine which Navy facilities are communicating with other Navy facilities via the commercial Internet infrastructure.
- (U) Develop an technical architecture that can provide the needed interfaces for achieving distributed force coordination between the command and control information grid (non real-time) and the Combat System (real-time) grid in support of network centric speed of command and force synchronization.
- (U) Develop a scaleable architecture for a consistent COP/CTP that portrays a coherent visualization of the battlespace among distributed decision makers from CINC to unit level.

- (U) ($1,178) Portion of extramural program reserved for Small Business Innovation Research assessment in accordance with 15 USC 638.

3. FY 2000 Plan:

- (U) ($1,000) SHORE FACILITIES MATERIALS.
  - (U) Characterize long-term time dependent system behavior and stress rupture response under sustained stress for modular hybrid composite/concrete structural systems for long life-low maintenance shore facilities.
  - (U) Develop concepts for application of non-destructive evaluation (NDE) technologies to modular hybrid composite/concrete systems to enable cost effective approaches to repair.

- (U) ($8,976) AIRBORNE MATERIALS.
  - (U) Explore turbine case fabrication technology for orthorhombic Ti alloys. This will result in improved performance and lighterweight in Naval aircraft engines.
  - (U) Explore feasibility of oxidation resistant Mo-Alloy w/2500°F capability. This will result in revolutionary performance improvements in Naval aircraft engines.
  - (U) Continue evaluation of corrosion sensors in operational aircraft for implementation of condition based maintenance.

- (U) Evaluate corrosion prevention applique technology in operational carrier environments to reduce hazardous material disposal costs.
- (U) Identify chromate and cadmium replacement technologies for aircraft to conform with EPA regulations.

- (U) ($10,555) SEABORNE MATERIALS.
  - (U) Integrate composite and multifunctional technologies for reduced signature and weight in ship topside design.
  - (U) Develop innovative, more affordable processes for improved welding/joining of non-magnetic ship hull materials to reduce signature and provide mine countermeasures.
  - (U) Investigate non-magnetic alloys in regard to strength, fracture behavior, fabrication, and corrosion protection for ship hull application to reduce signature.
  - (U) Develop improved fire-resistant, low-cost composite material systems to enhance fire-fighting capability.
  - (U) Develop prediction capability for (UNDEX) loaded hull structural material with rupture to improve warfighting ability.
  - (U) Continue evaluation of coatings technology for non-magnetic ship hull applications to reduce signature.
  - (U) Evaluate corrosion sensors in ballast tanks of operational ships to enable implementation of condition based maintenance.
  - (U) Evaluate upgraded seawater valves in operational ship systems to reduce life cycle costs.
  - (U) Transition guided wave ultrasonics corrosion/erosion detection technology to fleet to enable implementation of condition based maintenance.

- (U) ($1,432) MISSILE/SPACE MATERIALS.
  - (U) Investigate Refractory metal (Hf, Ta) spraying process for fabrication of low-cost metal nozzles which will increase performance and reduce cost in missile engines.
  - (U) Develop oxidation models for ceramic systems of interest (HfC, HfW, HfB2) which will result in improved performance and reduce development costs for missile propulsion systems.

- (U) ($7,368) MULTI-MISSION MATERIALS.
  - (U) Explore new formulations of phthalocyanines that do not show performance degradation at high fluences (energy/area) for advanced laser eye and device protective devices.

- (U) Establish industrial fabrication processes for tubules and formulated composites for transition to fleet applications.
- (U) Demonstrate the performance of single crystal piezoelectrics (high sensitivity-2 Octave Bandwidth) in high frequency ultrasonic imaging transducers for torpedo guidance and mine detection.
- (U) Use of nanostructured oxide ceramic coatings will be demonstrated by fabrication and testing of selected components. Techniques for fabrication of nanostructured Ni-based alloy coatings will be developed for multi-mission applications.

- (U) ($9,789) RF SOLID STATE DEVICE AND CONTROL COMPONENTS.
  - (U) Demonstrate highly compact, high Q, tunable notch filter for T/R module applications.
  - (U) Demonstrate gallium nitride heterojunction field effect power transistor for 6 - 18 GHz operation for next generation E/M power amplifiers.
  - (U) Continue the development of gallium nitride based heterojunction bipolar transistor in the 1 – 18 GHz spectrum and connected as class B, push-pull for maximum efficiency and linearity for ultra wideband MPM applications.
  - (U) Demonstrate compact varactor tuned filter for T/R module applications.
  - (U) Demonstrate 25 watt GaN X-band amplifier for high power transmitter applications.
  - (U) Develop a programmable time delay hybrid circuit for improving co-site interference canceller accuracy over VHF operation bandwidth.
  - (U) Demonstrate SiGe T-Gate structures with Ft, Fmax > 100 GHz and equal p/n channel MOSFET mobilities to minimize CMOS circuit area.
  - (U) Apply and transition the technology of CMOS low voltage, low power sub 250nm – 100nm SiGe with T-gate structure in 50nm – 30nm TFSOS for the implementation (design, fabrication and demonstration) of K-band (40 GHz) low noise analog front-end receiver functions and 4 bit, 20 gigasamples/sec A/D converters using two time-interleaved 4 bit, 10 GSPS A/D converters.
  - (U) Demonstrate a 25 channel Continuous Wavelet Transform circuit for EW signal identification.

- (U) ($10,000) VACUUM ELECTRONICS.
  - (U) Develop an ultra-wideband MPM for EW applications.
  - (U) Develop a vacuum power booster for a 2-D array MPM for phased array applications.

- (U) Develop an airborne compatible gyroklyston with gridded electron gun for high pulse repetition frequency (PRF) radar to provide unambigous doppler at W band.
- (U) Develop high speed design codes for coupled cavity TWTs to provide for reduced noise in Navy shipboard illuminator applications.
- (U) Develop high brightness scandate cathode in high perveance TWT to increase reliability through lower operating temperature.

- (U) ($5,867) E/O TECHNOLOGY.
  - (U) Demonstrate an adaptive two color IRFPA for increased clutter and background rejection
  - (U) Demonstrate a three color IR detector to enable discrimination against advanced countermeasures.
  - (U) Develop a small pixel color discriminating IRFPA for wide field of view shipboard IRST and theatre missile defense interceptor applications.
  - (U) Optimize fiber fabrication techniques to achieve goal of 0.1 dB/m loss in 2 - 5 μm region and proof-test fibers to goal of 50,000 psi for EW applications. Reduce AR coatings reflectance to 2% in 2 - 5 μm region. Improve optical power damage threshold to achieve goal of 1.5 GW/cm2 in AR coated fibers. Develop cabling techniques for 10 m length cables which are ruggedized and meet system environmental specifications.
  - (U) Select final approach (e.g. lateral epitaxial overgrowth or compliant substrate) for the synthesis of low defect materials for reducing the cost of infrared materials and improving their performance.

- (U) ($12,613) ADVANCED MULTIFUNCTIONAL RF SYSTEM SUPPORT TECHNOLOGY. With the advances that are currently being made in electronics there exists a strong opportunity to realize multifunctional systems that integrate the functions of radar, EW, and communications into a pair of transmit and receive apertures over a broad bandwidth. It should be noted that this program is in contrast to the Air Force (AF) and Joint Strike Fighter (JSF) programs in that it treats both the transmit and receive functions in separate apertures. This approach avoids the need for time allocation of different RF functions and therefore offers the opportunity for more massive integration of RF functions into the pair of apertures. As a result, this integrated thrust has been formed and the current program enhanced to capitalize upon ongoing and planned applied research to develop RF solid state and photonic devices. This program is coordinated with JSF and the AF and has an oversight group with representatives from Space and Warfare Systems Command (SPAWAR), Naval Air Systems Command (NAVAIR), Program Executive Office (PEO)DD-21, PEO

Theater Air Defense/Surface Combatant (TAD/SC), Common Support Aircraft (CSA), N86 and N6. Specific efforts within this thrust include:
- (U) Demonstrate moderate power continuous wave (CW) ultra broadband (1 - 18 GHz), ultra linear (cross modulation products 28dbm below fundamental signal) compact amplifiers suitable for use in next generation multifunctional wide area surveillance systems and also suitable for use as drivers in microwave power modules.
- (U) Develop low parasitic bipolar microwave power amplifier for the 1 - 5 GHz spectrum.
- (U) Demonstrate a 100 GHz logic-derived microwave synthesizer for 1 - 5 GHz output (sans modulator)
- (U) Select final approach to A/D converter with real time adjustment of resolution vs bandwidth and suitable for use with advanced multifunctional RF systems.
- (U) Continue the development of a multicomponent model for antenna isolation and coupling to assess options for minimizing interference and self-jaming of multifunciton apertures.

- (U) ($10,357) COMMAND AND CONTROL AND COMBAT SYSTEMS.
  - (U) Demonstrate distributed software that will enable users at remote locations to collaborate for effective planning using 3D, interactive virtual reality displays with objects having physical realism.
  - (U) Precisely quantify image spatial domain error propagation and further study the problem of feature detection in wavelet space.
  - (U) Integrate the Software Requirements Specification tool that combines the three decision procedures (term rewriting, Reduced Ordered Binary Decision Diagrams, and a constraint solver) into the existing toolset. Evaluate the prototype tool as well as the TAME tool (which uses a mechanical prover to analyze properties of time automata models) for detecting violations of application properties in timed requirement specifications.
  - (U) Under the ‘System of Systems’ program, demonstrate chip out technology and develop/understand transmitting the targeting template through additional compression stages in the presence of channel noise. Introduce techniques to optimize joint channel source encoding to maximize performance and adapt the system.
  - (U) Demonstrate a distributed software infrastructure prototype development for use in integrating COTS tools (PCIS2) by incorporating Software Process, Configuration Management, and wide-area traceability capabilities.
  - (U) Continue development of interface specification and architecture merging command and control functions and platform battle management in a secure distributed network combining non-real-time and real-time databases and operations.

FY 2000 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 1999

BUDGET ACTIVITY: 2 PROGRAM ELEMENT: 0602234N
PROGRAM ELEMENT TITLE: MATERIALS, ELECTRONICS, AND COMPUTER TECHNOLOGY

B. (U) PROGRAM CHANGE SUMMARY:

	FY 1998	FY 1999	FY 2000
(U) FY 1999 President's Budget:	70,174	77,617	81,026
(U) Appropriated Value:		88,117	
(U) Adjustments from FY 1999 PRESBUDG:	+6,020	+10,081	-3,069
(U) FY 2000 PRESBUDG Submission:	76,194	87,698	77,957

(U) CHANGE SUMMARY EXPLANATION:

(U) Funding: The FY 1998 adjustment reflects actual update adjustments (+3,245), Small Business Innovation Research reduction (-225) and Terfenol-D Line Item Veto Override (+3,000). FY 1999 adjustment reflects the following Congressional additions: Materials Micronization (+4,000), Advanced Materials Intelligent Processing Center (+3,000), High Temperature Superconductors for Propulsion (+2,000), Carbon-Carbon Materials for Reentry Vehicles (+1,500), High Thermal Conductivity Fibers for Thermal Management Materials (+2,500), Superconducting Waveform Generator (+1,000) and Silicon Carbide Semiconductor Materials (+3,500), Congressional Undistributed reductions (-419), and Congressional General reduction (-7,000). FY 2000 adjustment reflects Program adjustments (-2,817), Navy Working Capital Fund (NWCF) rate adjustment (+602), Civilian Pay Rates (+274), and Non Pay Inflation (-1,128).

(U) Schedule: The reductions in FY 2000 as noted above, preclude certain aspects of expansion, risk reduction and early transition in the following thrust areas: Airborne Materials, Shore Facilities, and Multi-mission Materials, RF Solid State Devices and Control Components, and Command, Control and Combat Systems. Specific areas affected include: research in the area of integration of electrically switchable radome materials into airborne systems; engineered lumber for pilings; new composite concrete; transitioning high performance A/D power converters to military systems; verification and validation of software supporting Network-Centric Warfare; multi-level security software for Navy Systems; and integration of real and non real-time Navy information systems.

(U) Technical: The thrust areas of Airborne Materials, Shore Facilities, RF Solid State Devices and Control Components, and Command and Control and Combat Systems will see an overall decrease that will increase the

technical and transition risk for front frame technology for aircraft engines, especially F414 in the F/A-18E/F; increase the technical risk for transition of engineered lumber for pilings; increase the technical risk for transition of laser protective materials; increase the technical risk and development time of A/D converters that can be used for all sensor systems; increase vulnerability to intrusion and computer security threats for Navy COTS based Information Systems, as well as increase the system acquisition certification and maintenance costs for Network-Centric Warfare Systems.

C. (U) OTHER PROGRAM FUNDING SUMMARY: Not applicable.

(U) RELATED RDT&E:
(U) PEs 0601102A, 0601102F, 0601153N (Defense Research Sciences)
(U) PEs 0602105A, 0602102F (Materials Technology)
(U) PEs 0602705A, 0602709A, 0602204F, 0602702F (Electronic Devices Technology)
(U) PEs 0602783A, 0602783A, 0602202F, 0602702F, 0603728F, 0602301E, 0603226E (Computer Technology)
(U) PE 0602303A (Missile Technology)
(U) PE 0602601A (Combat Vehicle and Automotive Technology)
(U) PEs 0602702F, 0602232N (Command, Control and Communications)
(U) PE 0602786A (Logistics Technology)
(U) PE 0602111N (Air and Surface Launched Weapons Technology)
(U) PE 0602121N (Ship, Submarine and Logistics Technology)
(U) PE 0602122N (Aircraft Technology)
(U) PE 0602314N (Undersea Warfare Surveillance Technology)
(U) PE 0602323N (Submarine Technology)
(U) PE 0602270N (Electronic Warfare Technology)

(U) This PE adheres to Defense Technology Area Plan (DTAP) and Defense Technology Objective (DTO) Agreements on Advanced Materials, Electronics and Computer Technology with oversight provided by the Joint Directors of Laboratories and Joint Engineers. This PE is integrated with the 6.1 and 6.2 PE's shown above and is fully coordinated with efforts in DoD through Joint Director of Laboratories and Defense Task Area Plans activities.

D. (U) FUNDING PROFILE: Not applicable.